University of Jordan
Faculty of Engineering & Technology
Chemical Engineering Department

الجامعــة الاردنية
كلية الهندسة و التكنولوجيا
قسم الهندســة الكيميائية

$\frac{5}{10}$

Heat and Mass Transfer Operations **First semester 2015/2016**

Student name: [redacted] **Student No.:** [redacted] **Serial No.:** [redacted]

Quiz #1 **October 28, 2015**

In order to concentrate 6000 kg/h of an NaOH solution containing 10 wt% NaOH to a 20 wt%, a single effect evaporator is being used with an area of 37.6 m². The feed enters at 21.1 °C. Saturated steam at 110 °C is used for heating and the pressure in the vapor space of the evaporator is 51.7 kPa. Calculate the steam economy and the overall heat transfer coefficient. Take boiling point elevation into considerations.

$F = 6000$ Kg/h

$x_F = 0.1$

$x_L = 0.2$

$A = 37.6 m^2$

$T_F = 21.1°C$

$T_S = 110°C$

$P = 51.7$ KPa $\rightarrow T_1 = ~~81~~.82°C = 180°F$

Economy, U ?

Heat Balance:

$F h_F + S\lambda = L h_L + V H_V$

$\Rightarrow S\lambda = L h_L + V H_V - F h_F$

~~$S\lambda = (F-V)h_L + VH_V - Fh_F$~~

~~$S\lambda = Fh_L - Vh_L + VH_V - Fh_F$~~

~~$S\lambda = V(H_V - h_L) + F(h_L - h_F)$~~

From steam tables @ 110°C

$\Rightarrow \lambda = 2226$ KJ/Kg

h_F @ 21.1°C from Enthalpy-conc. chart.

$\Rightarrow h_F = 110$ KJ/Kg

$\Rightarrow Bp_{soln} = 190°F$

$Bp_{soln} > Bp_{H_2O}$

$\rightarrow$ vapor is superheated

@190°F $\rightarrow H_V =$

$\rightarrow h_L =$

~~Ma~~ Mass Balance:

$F = V + L$

$x_F F = y_V V + x_L L$ ($y_V = 0$)

$x_F F = x_L L$

$\Rightarrow L = \frac{~~1200~~ 600}{0.2}$

$\Rightarrow$ **L = 3000 Kg/h**

$\Rightarrow$ **V = 3000 Kg/h**

~~Heat Balance~~

Economy = V/S

$S\lambda = UA\Delta T$

$S\lambda = UA(T_S - T_1)$

$\Rightarrow U = \frac{S\lambda}{A(T_S - T_1)}$

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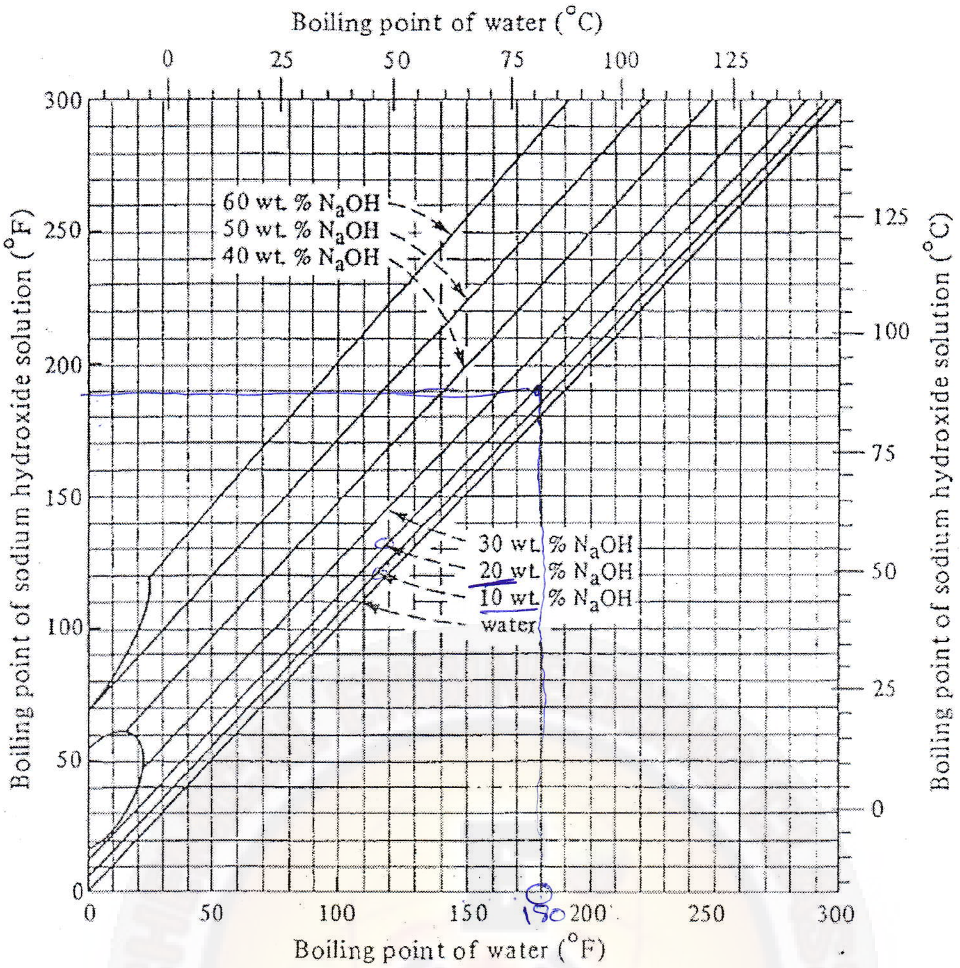

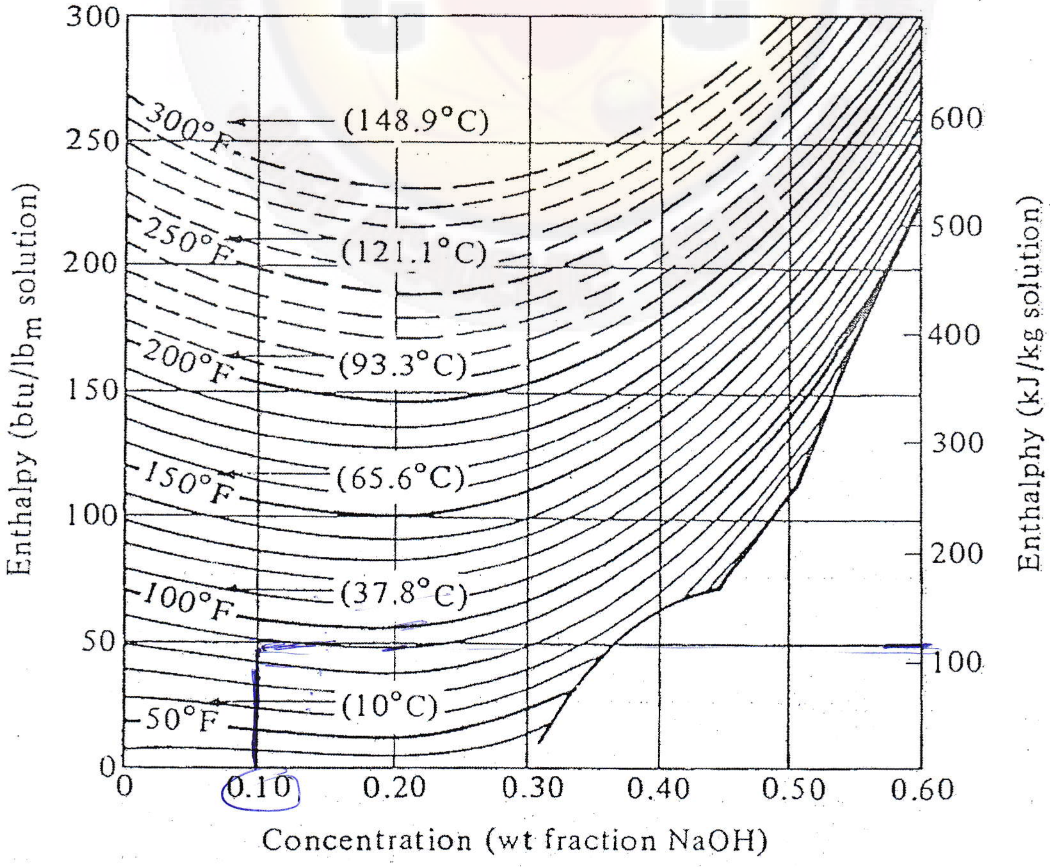

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Heat and Mass Transfer Operations **First semester 2015/2016**

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Quiz #2 **November 11, 2015**

Below, the liquid-liquid extraction phase diagram is based on mass composition:

a) What are the components pairs that are completely miscible?

Only A & C

b) What are pairs that are partially miscible?

C&S , A&S

c) What are the pairs that are pairs that are completely immiscible?

None

d) Show the raffinate and extract phases on the diagram.

e) Find the mass composition of the feed

$x_F = 0.37$

f) With one stage extraction, the minimum allowable amount of solvent is used for 80 kg of feed. Find this minimum amount of solvent and the amounts of extract and raffinate.

$F = 80$ Kg

$x_F = 0.37$

$M = S + F$

$S = 100$ Kg

$M = 100 + 80$

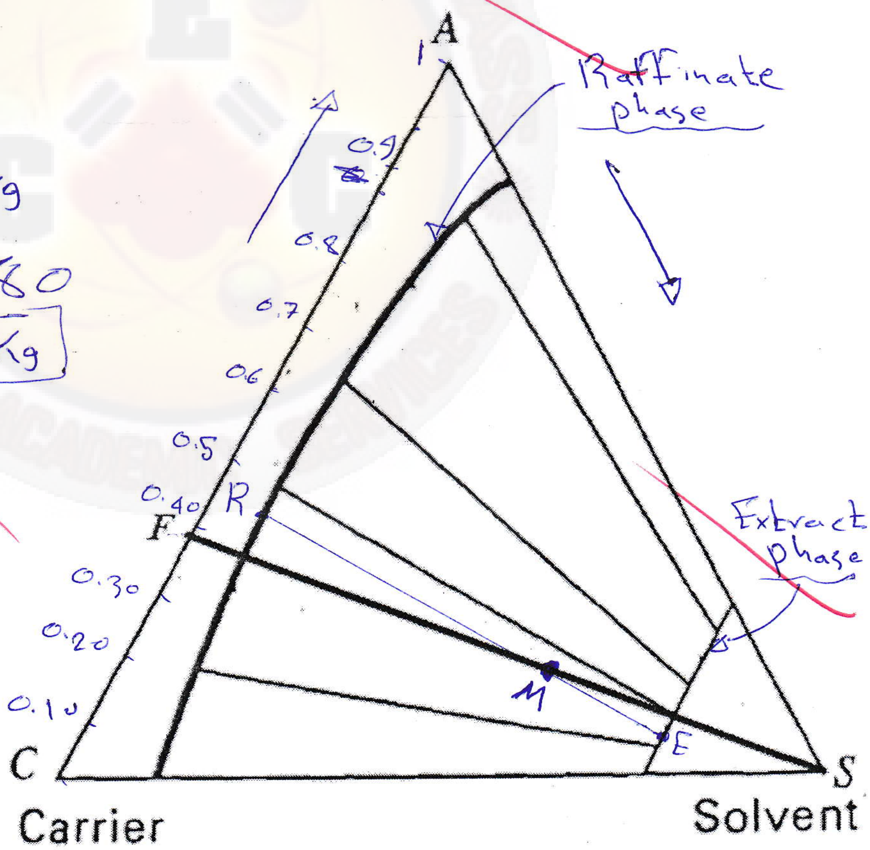
$M = 180$ Kg

locate M

$\frac{S}{M} = \frac{\overline{FM}}{\overline{SF}}$

$\frac{100}{180} = \frac{\overline{FM}}{9}$

$\Rightarrow \overline{FM} = 5$



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Heat and Mass Transfer Operations **First semester 2015/2016**

Student name: [redacted] **Student No.:** [redacted] **Serial No.:** [redacted]

Quiz #3 **November 23, 2015**

Define leaching process and explain the transfer rate steps involved in it.

It's a type of chemical processes where you can extract a specific liquid (solute) from a solid using a ~~solvent~~ suitable solvent.

For the steps of transfer rate they include ~~the~~ as a start for the solvent to pass by the solid then dissolves the solute for solubility reasons, then it comes back, ~~two~~.

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Heat and Mass Transfer Operations **First semester 2015/2016**

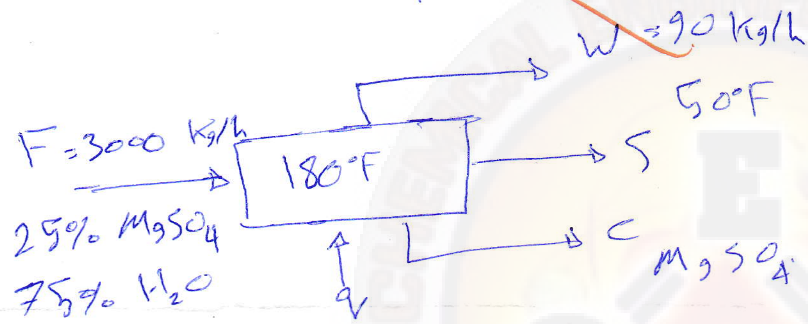
Student name: [redacted] **Student No.:** [redacted] **Serial No.:** [redacted]

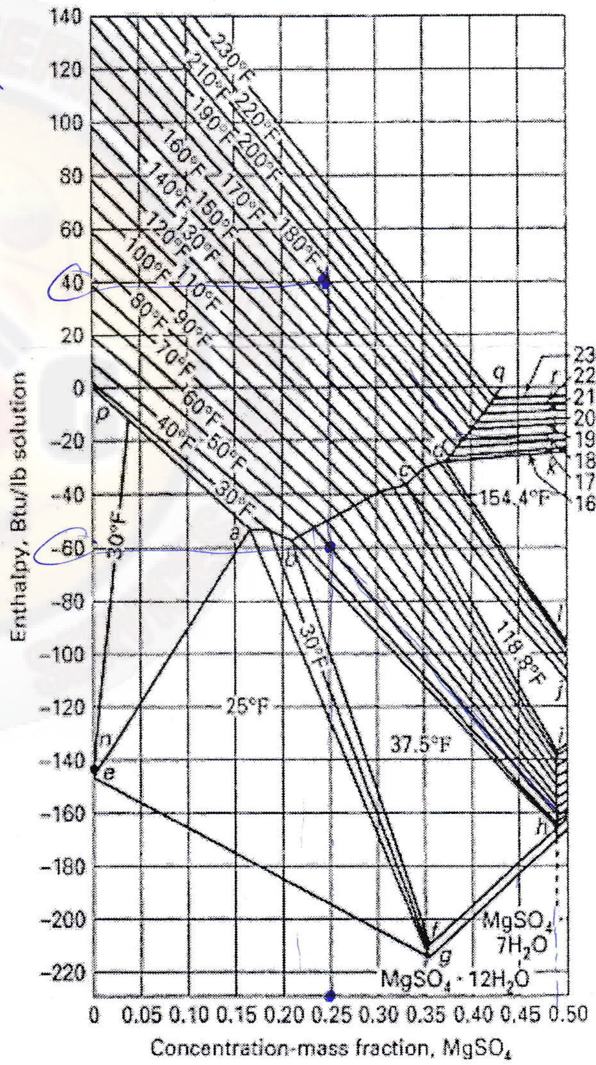
Quiz #4 **December 14, 2015**

A 3000 kg/h aqueous solution of $MgSO_4$ (25 wt% $MgSO_4$) at 180 °F is fed continuously to vacuum crystallizer. The equilibrium temperature is 50 °F. During this steady-state process, 4% of the total water fed to crystallizer is evaporated. It was found that the crystal growth rate is constant at around 0.18 mm/h. The crystallizer has a residence time of 1.5 h. The molecular weight of $MgSO_4$ = 120.4 g/mol.

a. What type of crystals will be formed? Why?
b. Calculate the yield of crystals.
c. Calculate the net heat added/removed from crystallizer.
d. Use MSMPR model to estimate the average and the predominant crystal size.

F = 3000 Kg/h , x_F = 0.25





a) Crystals will be formed as $MgSO_4 \cdot 7H_2O$ because it lies on the region on the graph. (1)

b) C = ?

W = 0.04 * 0.75 * 3000

W = 90 Kg/h (2)

Total M.B.

F = S + C + W

3000 = S + C + 90 — (1)

$MgSO_4$ M.B.

$x_F F = x_S S + x_C C + 0 \Rightarrow (0.25)(3000) = x_S S + x_C C$

From graph ⇒ ~~0.01~~ x_C = 0.48

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→

$x_s = 0.2$

$\Rightarrow 750 = 0.2\, x_s S + 0.48\, C$

$\Rightarrow S = 2310$ Kg/h , $C = 600$ Kg/h

c) $q = W_v h_v + h_2 (S + C) - F h_1$

assume to neglect it.

~~$q = (0) + (-60)(2310 + 600) - (3000)(40)$~~

From graph

$h_1 = 40$ Btu/lb soln $= 88$ Btu/Kg soln

$h_2 = -60$ Btu/lb soln $= -132$ Btu/Kg soln

(3)

1 Kg = 2.2 lb

$\Rightarrow q = (-132)(2310 + 600) - (3000)(88)$

$q = -648120$ Btu/h

↳ must be give off & removed from the crystallizer

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Quiz #5 **December 30, 2015**

Air at 40 °C and 20% relative humidity enters an adiabatic pray chamber at a rate of 100 m^3/h. The air is adiabatically humidified to 50% relative humidity. Find:

a) The outlet temperature of the humidified air.

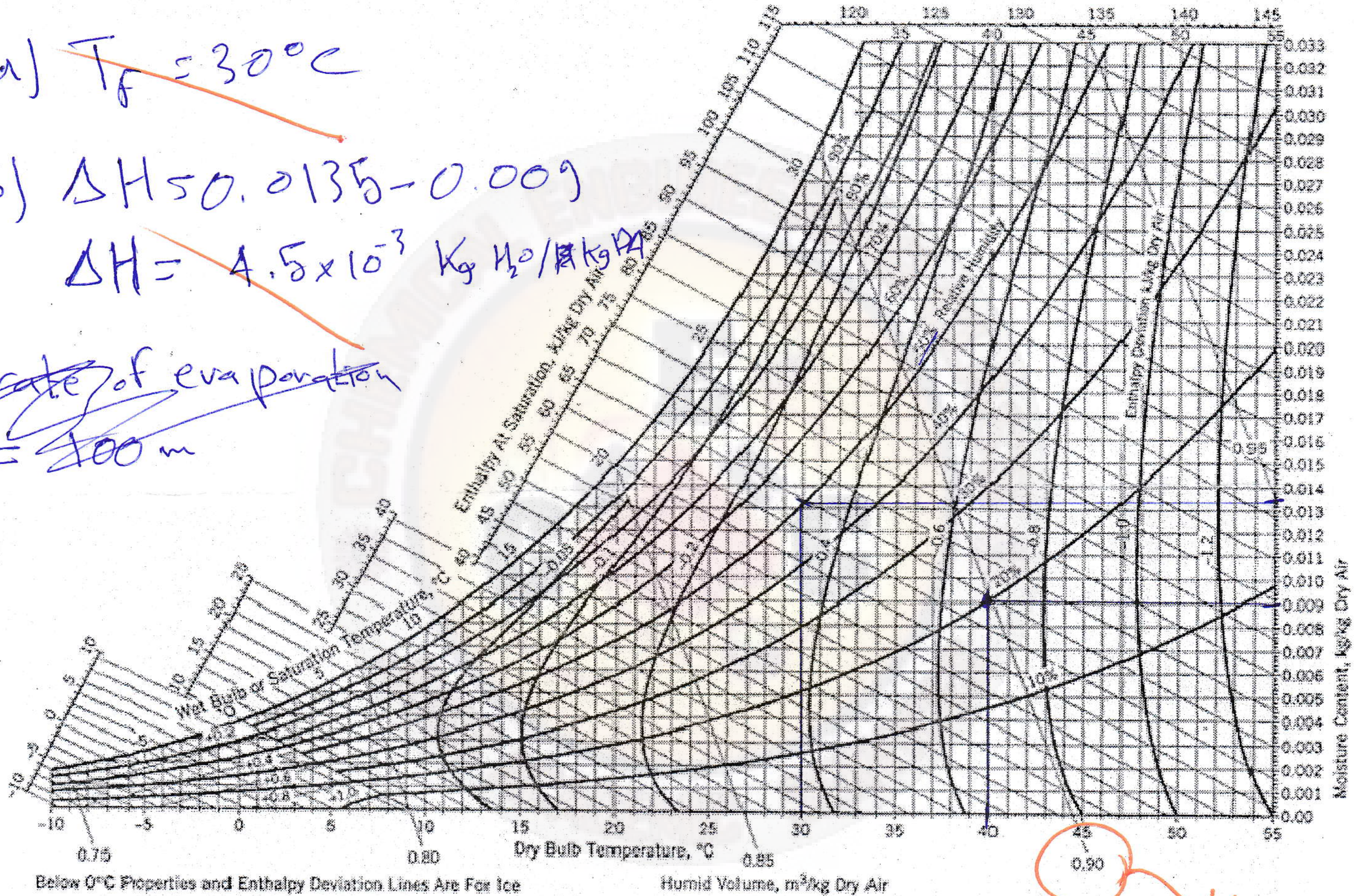
b) Rate of water evaporation in the spray chamber.

a) $T_f = 30°C$

b) $\Delta H = 0.0135 - 0.009$

$\Delta H = 4.5 \times 10^{-3}$ Kg H_2O/kg DA

~~rate of evaporation = 100 m~~



v_H

rate of evaporation $= 100 \frac{m^3}{h} * \Delta H / 0.9$

$= 100 * 4.5 \times 10^{-3}$

$= 0.45$ m³ H_2O/h

mass flow rate of air

$= \frac{100}{\Delta H} =$

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